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Mission Highlights

STS-75

IS-1996-02-001.075JSC
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Satellite breaks free after surpassing initial expectations

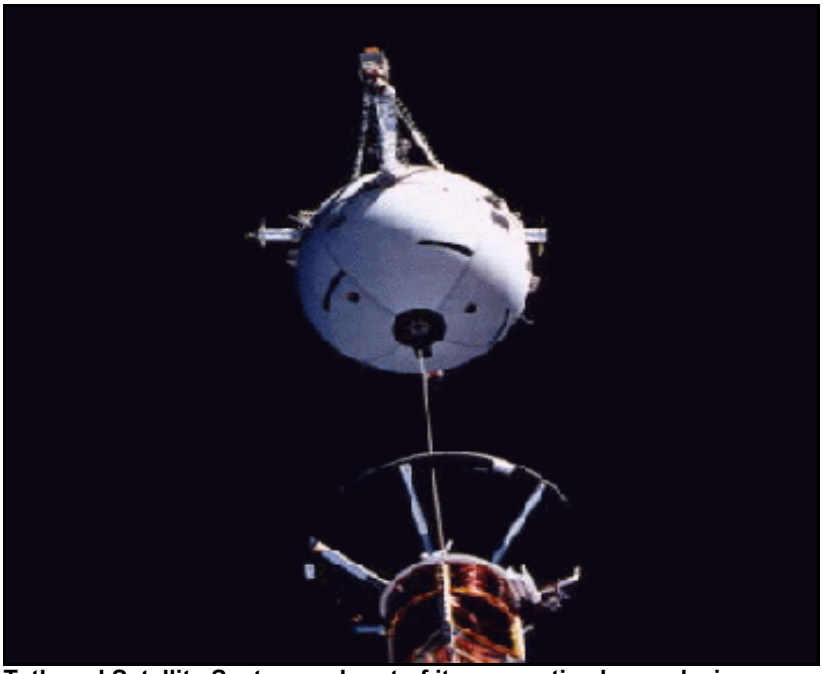
The 19th mission of the Space Shuttle *Columbia* carried the reflight of the Tethered Satellite System (TSS) and the third of the United States Microgravity Payload (USMP). Experiments being conducted during deployment operations of the TSS were surpassing scientists' expectations when the tether broke, slinging the satellite away from orbiter.

"We got a lot of information on tether dynamics," said Lee Briscoe, Mission Operations representative. "We learned a lot about deploying tethered satellites and we were able to verify our deployment models and procedures work."

During deployment, TSS scientists collected data on a variety of experiments including the generation of electrical current. Tether voltages as high as 3,500 volts were developed and scientists said the TSS could produce more power than they originally thought.

The satellite broke away from *Columbia* about 7:30 p.m. CST on February 25, as it was nearing the full extent of its 12.8 mile deployment. The tether had been switched to a passive mode, and there was no electrical current flowing at the time of the break. For the next two days, Mission Control continued to collect data from TSS for science investigations until the batteries lost power.

With work at a halt on the TSS, the crew turned toward conducting extensive research with the USMP. Mission managers even extended the flight for a day to support the many successful scientific investigations.



Tethered Satellite System and part of its supportive boom device during deployment operations.

Space Shuttle *Columbia*

February 22-March 9, 1996

Commander:	Andrew M. Allen
Pilot:	Scott J. "Doc" Horowitz
Mission Specialists:	Jeffrey A. Hoffman Maurizio Cheli Claude Nicollier Franklin R. Chang-Diaz
Payload Specialist:	Umberto Guidoni

Astronauts Jeff Hoffman and Franklin Chang-Diaz hold up a sign to celebrate the fact that each has surpassed the 1,000-hour mark in space.

Researchers at the Rensselaer Polytechnic Institute in Troy, NY, had the distinction of being the first university to send a command to an on-board experiment, the Isothermal Dendritic Growth Experiment (IDGE). Throughout the mission, the Rensselaer Operations Control Center crew worked hand-in-hand with its counterparts at the Marshall Space Flight Center to analyze data produced by the IDGE experiment. The results of the first growth cycle soon became clear, as the first dendrite of this operational phase emerged in record time. The characteristics of these microscopic crystals help determine the strength and flexibility of products such as automobile engine blocks and jet engine turbine blades. The ultimate goal of the IDGE investigation is to improve ground-based materials processing for metals ranging from aluminum to steel.

Mission Events

An erroneous reading on some engine performance indicators added a few brief moments of excitement to the lift off of *Columbia* at 2:18 p.m. CST on Thursday, February 22, 1996. Flight controllers in Houston quickly responded that all engines were performing nominally. The shuttle continued to operate normally all the way to main engine cutoff to begin a two-week mission of scientific experimentation.

Much of the crew's time on Friday was spent verifying the health of the TSS in anticipation of its scheduled deployment. The crew also checked out and activated several other experiments.

With all equipment checked out, deploy of the TSS began on Sunday, February 25, 1996, at 2:45 p.m. CST. An hour later, the TSS had passed the distance of maximum deployment achieved on its previous flight, 843 feet, during the STS-46 mission. As the satellite was nearing the end of its planned 12.8 mile distance at about 7:30 p.m. CST, the tether broke and the TSS immediately began accelerating away from *Columbia* at a rapid rate as a result of normal orbital forces. The tether apparently snapped near the top of the 39-foot TSS boom in *Columbia's* cargo bay.

On Monday, following the retraction of the remaining length of tether and stowage of the mast for the TSS, the astronauts refocused their attention to operation of a multitude of experiments with the USMP. The materials science investigations including crystal growth, materials solidification and fluid dynamics. The shuttle and ground crews continued to track and gather data from the TSS throughout the mission.

By Friday, March 1, experiments into convection and the behavior of flame patterns in microgravity were the focus of activity on *Columbia*. Among Sunday's activities, crew members worked with an experiment called the Forced Flow Flamespreading Test which studied how flames react in the absence of gravity. The investigations were designed to provide additional data for improved fire-fighting techniques on Earth.

The *Columbia* completed its 16-day science mission on Saturday, March 9, 1996, with a 7:58 a.m. CST landing at the Kennedy Space Center in Florida

Payload Descriptions

Advanced Automated Directional Solidification Furnace (AADSF): A semiconductor's usefulness is determined by how atoms are ordered within the crystal's underlying three-dimensional structure. These materials, when produced under the influence of gravity, often suffer structural damage that limits the crystal's usefulness. The effects of gravity on the orbiting spacecraft are roughly a million times less than experienced on the ground. This experiment flew to help researchers develop processes and materials that perform better and cost less to produce. The principal investigator for this experiment was the NASA Langley Research Center, Langley, VA.

Critical Fluid Light Scattering Experiment (Zeno): This investigation explored an unusual state of matter by measuring the density of the element xenon at its critical point, a unique set of conditions when it is literally on the edge of simultaneously being in a gaseous phase and a liquid phase. Accurate measurements of a fluid's physical properties when very close to the critical point cannot be made on Earth because gravity causes the fluid to layer, with respect to density (vapor on top, liquid below), severely at the temperatures of most significance. The orbital environment permits measurements to be made within a few millionths of a degree of the critical temperature. The principal investigator for this experiment was the Institute for Physical Science and Technology, University of Maryland, College Park, MD.

Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit (MEPHISTO): MEPHISTO was a cooperative program between NASA, the French Space Agency and the French Atomic Energy Commission, with the goal of understanding how gravity-driven convection affects the production of metals, alloys and electronic materials. Analyses of samples produced on orbit were conducted by science and technical teams to improve processes for making products ranging from alloys for airplane turbine blades to electronic materials. The principal investigator for this experiment was the Center for Nuclear Study, Grenoble, France.

Space Acceleration Measurement Systems (SAMS): When the space shuttle is in orbit, the effects of gravity are reduced by close to one million

Pilot Scott Horowitz looks over tools used to perform an in-flight maintenance chore on the mid-deck.

times. However, disturbances happen when crew members move about and equipment is operated, as well as when the shuttle maneuvers by firing thrusters and even when it experiences subtle atmospheric drag. USMP-3 scientists depended on measurements of minute changes in the orbital environment to tweak their experiments and improve scientific data collection, as well as to determine how such vibrations or accelerations influence experiment results. The principal investigator for this project was the NASA Lewis Research Center, Cleveland, OH.

Orbital Acceleration Research Experiment (OARE): This experiment helped scientists obtain data to make the best possible use of the low-gravity environment. While the orbiting shuttle offers a remarkably stable ride for space-based experiments, it does experience some low-level disturbances from the shuttle's orientation, atmospheric drag and venting of liquids or gases, among others. USMP-3 experiments used this acceleration data to complement the data provided by SAMS and improve research results. This project was conducted by NASA Lewis Research Center, Cleveland, OH.

Middeck Glovebox Facility (MGBX) Combustion Investigations: This facility was a contained space where potentially hazardous materials were handled and crew members performed operations that are impractical in the open cabin environment. The facility provided power, air and particle filtration, light, data collection, real-time monitoring, and sensors for gas, temperature, air pressure and humidity. For each experiment, a crew member removed the experiment kit from stowage and placed it through the glovebox door, then tightly sealed the opening. Using gloves that project into the facility, they set up and conducted the experiment in this safe enclosure. The project was sponsored by NASA Marshall Space Flight Center, Huntsville, AL.

Forced-Flow Flamespreading Test (FFFT): Scientists who study combustion want to know the details of how air motion affects flame spreading to be able to better control fires that may occur on orbit. For the FFFT, a crew member placed small solid fuel samples (flat paper and cellulose cylinders) into the test module; sealed the module in the Middeck Glovebox; established air flow; heat, then ignited the fuel sample; and recorded the results. The test was sponsored by NASA's Lewis Research Center, Cleveland, OH.

Radiative Ignition and Transition to Spread Investigation (RITSI): Fires in spacecraft pose a significant threat. A short-circuit in an electrical system or overheated electrical components could ignite flammable material. Toxic gases can quickly poison the air, and fire extinguishers can damage critical equipment. This experiment sought to understand the conditions that lead up to ignition in order to prevent fires on orbit. The investigation was sponsored by the National Institute for Standards and Testing, Gaithersburg, MD.

Comparative Soot Diagnostics (CSD): This experiment provided the first measurements of quasi-steady, microgravity flames and provided data useful for understanding soot processes on Earth. This data was studied for its applicability to the design and operation of future spacecraft smoke detection systems. Investigation was sponsored by NASA's Lewis Research Center, Cleveland, OH.

Commercial Protein Crystal Growth (CPCG): This payload processed nine different proteins seeking the development of new therapeutic treatments for infections, human cancers, diseases caused from hormone disorders, and Chagas disease. It was the first joint U.S.-Latin American experiment in protein crystal growth. The project brought together a small team of investigators from Costa Rica, Chile and the United States. It involved the crystallization in microgravity of a DNA-grown protein expressing key features of the parasite that causes Chagas Disease. The high resolution resulting from space grown crystals could pave the way for the development of effective pharmaceuticals to combat this debilitating disease and lead to an effective vaccine.

CPCG-09 used the Commercial Vapor Diffusion Apparatus (CVDA) to produce protein crystals of

Payload Specialist Umberto Guidoni, wearing the partial pressure launch and entry garment, prepares for de-orbit operations.

significantly higher quality than ever grown on Earth before. The flight of CPCG-09 was sponsored by the Space Processing Division of the Office of Space Access and Technology, as part

of NASA's commercial development of space program.

CREW BIOGRAPHIES

Commander: Andrew M. Allen (Lt. Col., USMC). Allen, 40, was born in Philadelphia, PA. He received a bachelor of science degree in mechanical engineering from Villanova University.

Allen was a member of the Navy ROTC unit and received his commission in the United States Marine Corps at Villanova University. He attended and graduated from the Marine Weapons & Tactics Instructor Course, the Naval Fighter Weapons School (Top Gun) and the United States Navy Test Pilot School at Patuxent River, MD.

Allen's NASA technical assignments have included: Astronaut Office representative for all space shuttle issues related to landing sites, landing and deceleration hardware, including improvements to nosewheel steering, brakes and tires, and drag chute design; The Shuttle Avionics Integration Laboratory (SAIL), that oversees, checks, and verifies all shuttle flight control software and avionics programs; served as technical assistant to the Flight Crew Operations Director who is responsible for and manages all flight crew operations and support; was the lead of the Astronaut Support Personnel Team that oversees shuttle test, checkout, and preparation at Kennedy Space Center; served as special assistant to the Director of the Johnson Space Center in Houston, TX; was lead of a Functional Workforce Review at the Kennedy Space Center, FL, to determine minimal workforce and management structure requirements that allow maximum budget reductions while safely continuing shuttle flight operations. Allen was the pilot on STS-46 in 1992, and STS-62 in 1994, and with the completion of STS-75, had logged more than 903 hours in space.

Pilot: Scott J. "Doc" Horowitz, Ph.D. (Lt. Col., USAF). Horowitz, 38, was born in Philadelphia, PA, but considers Thousand Oaks, CA, to be his hometown. He received a bachelor of science degree in engineering from California State University at Northridge; a master of science degree in aerospace engineering and a doctorate in aerospace engineering from Georgia Institute of Technology.

Scott worked as an associate scientist for the Lockheed-Georgia Co., Marietta, GA, where he performed background studies and analyses for experiments related to aerospace technology to validate advanced scientific concepts. He graduated from Undergraduate Pilot Training at Williams Air Force Base, AZ. He then flew as a T-38 instructor pilot and performed research and development for the Human Resources Laboratory at Williams Air Force Base. Scott next attended the United States Air Force Test Pilot School at Edwards Air Force Base, CA. Additionally, Scott served as an adjunct professor at Embry Riddle University where he conducted graduate level courses in aircraft design, aircraft propulsion and rocket propulsion. As a professor for California State University, Fresno, he conducted graduate level courses in mechanical engineering including advanced stability and control.

With the completion of STS-75, Horowitz had logged 377 hours of space flight.

Mission Specialist: Jeffrey A. Hoffman (Ph.D.). Hoffman, 51, was born in Brooklyn, New York, but considers Scarsdale, NY to be his hometown. He received a bachelor of arts degree in astronomy (graduated summa cum laude) from Amherst College, a doctor of philosophy in astrophysics from Harvard University, and a masters degree in materials science from Rice University.

During three years of post-doctoral work at Leicester University, he worked on three rocket payloads, two for the observation of lunar occultations of x-ray sources and one for an observation of the Crab Nebula with a solid state detector and concentrating x-ray mirror. He designed and supervised the construction and testing of the lunar occultation payloads and designed test equipment for use in an x-ray beam facility which he used to measure the scattering and reflectivity properties of the concentrating mirror. During his last year at Leicester, he was project scientist for the medium-energy x-ray experiment on the European Space Agency's (ESA's) EXOSAT satellite and played a leading role in the proposal and design studies for this project.

He worked in the Center for Space Research at the Massachusetts Institute of Technology (MIT) as project scientist in charge of the orbiting HEAO-1 A4 hard x-ray and gamma ray experiment. He was also involved extensively in analysis of x-ray data from the SAS-3 satellite being operated by MIT, performing research on the study of x-ray bursts. Hoffman has authored or co-authored more than 20 papers on this subject since bursts were first discovered in 1976.

During preparations for the Shuttle Orbital Flight Tests, Hoffman worked in the Flight Simulation Laboratory at Downey, CA, testing guidance, navigation and flight control systems. He has worked with the orbital maneuvering and reaction control systems, with shuttle navigation, with crew training, and with the development of satellite deployment procedures. Hoffman served as a support crew member for STS-5 and as a CAPCOM (spacecraft communicator) for STS-8. Hoffman has been the Astronaut Office Payload Safety Representative. He has also worked on EVA, including the development of a high-pressure space suit for use on the International Space Station (ISS).

Hoffman made his first space flight as a mission specialist on STS 51-D, April 12-19, 1985 on which he made the first shuttle contingency space walk, in an attempted rescue of a malfunctioning satellite. He made his second space flight as a mission specialist on STS-35, December 2-10, 1990 that featured the ASTRO-1 ultraviolet astronomy laboratory. On his third flight, Hoffman was payload commander and mission specialist on STS-46, July 31-August 8, 1992 that deployed the European Retrievable Carrier (EURECA), an ESA-sponsored free-flying science platform, and carried out the first test flight of the TSS, a joint project between NASA and the Italian Space Agency.

Hoffman made his fourth flight as an EVA crew member on STS-61, December 2-13, 1993 when the Hubble Space Telescope (HST) was captured, serviced, and restored to full capacity through a record five space walks by four astronauts.

With the completion of his fifth space flight, Hoffman has logged more than 1,211 hours in space.

Mission Specialist: Maurizio Cheli, (ESA). Cheli, 36, was born in Modena, Italy. He graduated from the Italian Air Force Academy, and studied geophysics at the University of Rome. He received a master of science in aerospace engineering from the University of Houston.

After graduation from the Italian Air Force Academy, Cheli underwent pilot training at Vance Air Force Base, OK. He attended the Italian Air Force War College and graduated from the Empire Test Pilot's School, Boscombe Down, United Kingdom. He was selected by ESA for astronaut training.

Cheli's NASA technical assignments include: flight software verification in the Shuttle Avionics Integration Laboratory (SAIL) and remote manipulator system/robotics and crew equipment.

With the completion of this mission, Cheli has accumulated more that 377 hours of space flight.

Mission Specialist: Claude Nicollier, (ESA). Nicollier, 51, was born in Vevey, Switzerland. He received a bachelor of science in physics from the University of Lausanne and a master of science degree in astrophysics from the University of Geneva. He also graduated as a Swiss Air Force pilot, an airline pilot, and a test pilot.

Nicollier worked as a graduate scientist with the Institute of Astronomy at Lausanne University and at the Geneva Observatory. He then joined the Swiss Air Transport School in Zurich and was assigned as a DC-9 pilot for Swissair, concurrently participating part-time in research activities of the Geneva Observatory. He then accepted a Fellowship at the European Space Agency's (ESA) Space Science Department at Noordwijk, Netherlands, where he worked as a research scientist in various airborne infrared astronomy programs. He was selected by ESA as a member of the first group of European astronauts. Under agreement between ESA and NASA he joined the NASA astronaut candidates selected in May 1980 for astronaut training as a mission specialist.

His technical assignments in the Astronaut Office have included flight software verification in the Shuttle Avionics Integration Laboratory (SAIL), participation in the development of retrieval techniques for the TSS, Remote Manipulator System (RMS), and ISS robotics support. He attended the Empire Test Pilot School in Boscombe Down, England.

Nicollier flew on STS-46 in 1992, and STS-61 in 1993. With the completion of STS-75, Nicollier has accumulated more than 828 hours in space.

Mission Specialist: Franklin R. Chang-Díaz (Ph.D.). Chang-Diaz, 45, was born in San José, Costa Rica. He received a bachelor of science degree in mechanical engineering from the University of Connecticut and a doctorate in applied plasma physics from the Massachusetts Institute of Technology.

Following graduation he entered graduate school at MIT and obtained his doctorate in the field of applied plasma physics and fusion technology. He then joined the technical staff of the Charles Stark Draper Laboratory. His work at Draper was geared strongly toward the design and integration of control systems for fusion reactor concepts and experimental devices, in both inertial and magnetic confinement fusion. He developed a novel concept to guide and target fuel pellets in an inertial fusion reactor chamber. As a visiting scientist with the M.I.T. Plasma Fusion Center, he led the plasma propulsion program there to develop technology for future human missions to Mars. Chang-Díaz was appointed director of the Advanced Space Propulsion Laboratory at the Johnson Space Center where he continued his research on plasma rockets. He is an adjunct professor of physics at the University of Houston and has presented numerous papers at technical conferences and in scientific journals.

Inflight crew picture: Commander Andrew Allen is at bottom center. Clockwise from him are Franklin Chang-Diaz, Maurizo Cheli, Claude Nicollier, Scott Horowitz, Umberto Guidoni, and Jeff Hoffman.

STS-75 Quick Look

Launch Date: February 22, 1996
Time: 2:18 p.m. CST
Site: KSC Pad 39B

Orbiter: *Columbia*
OV-102-19th flight
Orbit/In.: 160 naut. miles
28.45 degrees

Mission Duration: 15 days, 17 hrs,
Landing Date: March 9, 1996
Time: 7:58 a.m. CST
Site: Kennedy Space Center

Crew: Andrew Allen, (CDR)
Scott Horowitz, (PLT)
Jeff Hoffman, (MS1)
Maurizio Cheli, (MS2)
Claude Nicollier, (MS3)
Franklin Chang-Diaz, (MS4)
Umberto Guidoni, (PS1)

Cargo Bay Payloads: Tethered Satellite
USMP-3
OARE

In-Cabin Payloads: Middeck Glovebox
Commercial Protein Crystal Growth

While undergoing astronaut training he was also involved in flight software checkout at the Shuttle Avionics Integration Laboratory (SAIL) and participated in the early ISS design studies. He was designated as support crew for the first Spacelab mission and served as on-orbit capsule communicator (CAPCOM) during that flight. He was leader of the astronaut support team at the Kennedy Space Center. His duties included astronaut support during the processing of the various vehicles and payloads, as well as flight crew support during the final phases of the launch countdown.

Chang-Diaz was a crew member on STS 61-C in 1986, STS-34 in 1989, STS-46 in 1992, and STS-60 in 1994. With the completion of STS-75, he had logged more than 1,033 hours in space.

Payload Specialist: Umberto Guidoni, Ph.D., Italian Space Agency (ASI). Guidoni, 41, was born in Rome, Italy. He received a bachelor of science in physics and a doctorate in astrophysics (summa cum laude) from the University of Rome.

As a staff scientist in the Solar Energy Division of the National Committee for Renewable Energy (ENEA), he was responsible for developing new techniques to characterize solar panels. He became a permanent researcher of the Space Physics Institute (IFSI-CNR) and was involved as co-investigator in the Research on Electrodynamic Tether Effects (RETE) experiment, one of the payloads selected for the TSS-1. He also designed the Ground Support Equipment (GSE) and supervised the design and testing of the Data Processing Unit (DPU) for the RETE experiment. He collaborated to the realization of a plasma chamber at IFSI, for laboratory simulations of electrodynamic tether phenomena and for characterization of plasma contactors in ionospheric environment. Guidoni was appointed project scientist of RETE. In this capacity he was responsible for the integration of the experiment with the Tethered Satellite System.

He was selected by the Italian Space Agency (ASI) to be one of the two Italian scientists trained as payload specialists for the TSS-1 mission and joined ASI as a member of the Astronaut Office. He was then relocated to the NASA Johnson Space Center to follow the training for STS-46/TSS-1 flight.

Guidoni supported the STS-46/TSS-1 mission by assisting the Science Team for on-orbit operations at the Payload Operations Control Center (POCC) at the Johnson Space Center for the duration of the mission.

With the completion of STS-75, Guidoni had logged more than 377 hours in space.

The crew patch depicts the Space Shuttle *Columbia* and the Tethered Satellite connected by a 21km electrically conducting tether. The Orbiter/Satellite system is passing through the Earth's magnetic field which, like an electric generator, will produce thousands of volts of electricity. *Columbia* is carrying the United States Microgravity Pallet to conduct microgravity research in material science and thermodynamics. The tether is crossing the Earth's terminator signifying the dawn of a new era for space tether applications and in mankind's knowledge of the Earth's ionosphere, material science, and thermodynamics.

Pic 1: 75701087-The Tethered Satellite System and part of its supportive boom device during deployment operations.

Pic 2: 75351037-Astronauts Jeff Hoffman and Franklin Chang-Diaz hold up a sign to celebrate the fact that each has surpassed the 1,000-hour mark in space.

Pic 3: 75355032-Payload Specialist Umberto Guidoni wearing the partial pressure launch and entry garment, prepares for de-orbit operations.

Pic 4: 75333032-Pilot Scott Horowitz looks over tools used to perform an in-flight maintenance chore on the mid-deck.

Pic 5: 75772020-Inflight crew picture: Commander Andrew Allen is at bottom center. Clockwise from him are Franklin Chang-Diaz, Maurizo Cheli, Claude Nicollier, Scott Horowitz, Umberto Guidoni, and Jeff Hoffman.